Model genebank concept: CIP Genebank as an example

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Abstract

There are more than 1300 genebanks in the world holding about 6.1 million accessions. Most of the smaller genebanks especially in developing countries require strengthening both in terms of genebank management system and competency of genebank staff. The Model Genebank Concept as the name indicated will establish a series of genebanks in the world where other genebanks can model upon. This paper described the concept and used the genebank of the International Potato Center as an example to illustrate the idea.

Keywords: Model genebank, genebank management, best practices, dynamic conservation, conservation strategy.

Introduction

There are some 1300 genebanks holding about 6.1 million accessions in the world (FAO 1996). Many of the smaller genebanks especially in developing countries require strengthening both in terms of genebank management system and competency of technicians. This is to certain extent related to sufficient funding in the CGIAR (Consultative Group on International Agricultural Research) genebanks where the World Bank has to intervene and funded a multi- millions two-phase Global Public Goods Project known as GPG1 (2004 to 2006) and GPG2 (2007-2009) specifically to upgrade the infrastructure and equipment, and to process the backlog of germplasm accessions accumulated. These two projects also focus on the standardization of genebanking management and processes in order to establish a series of best practices for genebanks in the CGIAR system and for general application in other genebanks. Some of these results have already been posted in CGIAR System-wide Genetic Resources Programme at http://cropgenebank.sgrp.cgiar.org/. The successful outcome of the projects at CIP is that the CIP Genebank became the first genebank in the world to obtain the high standard ISO 17025 accreditation. The Model Genebank Concept as proposed in this paper and as the name indicated will establish a series of genebanks in the world where other genebanks can model upon. This paper described the concept and used the genebank of the International Potato Center as an example to illustrate the idea.

History on the development of plant genetic resources conservation

The development of human civilization is connected to plants. The domestication of plants into crops about 10,000 years ago simultaneously in the old and new world allowed people to settle and establish concentrated populations and building ancient cities. Through generations of cultivation and selection, crop diversity and crop genetic resources were created. For example, Pliny (AD 23-79), a Roman naturalist was able to record fact about plants in his 37-volume *Historis Naturalis* (Natural History). However, the field of plant genetic resources was made significant through the work of N.I. Vavilov on the centers of origin of crops in the world (Vavilov 1926). Genebanks were built to store the collected germplasm. A master degree course on the Conservation and Utilization of Plant Genetic Resources was first offered in 1969 by the University of Birmingham, United Kingdom and this continues to date. This was followed by the publication of two landmarked books on plant genetic resources which served both as a standard and reference textbook at the early stage of the development in this field (Frankel and Bennett 1970; Frankel and Hawkes 1975). The IBPGR (the International Board for Plant Genetic Resources) was founded in 1974 by CGIAR in response to the rapid loss of crop genetic resources and the threat to agricultural development and food security. It was housed at the Food and Agriculture Organization of the United Nations (FAO) to coordinate and fund germplasm collection and conservation activities, and to set up standards and procedures relating to these. One of the earlier standard crop descriptors published was for cultivated potato by the International Potato Center in 1977, and to date descriptors of 94 crops have been published and the newest one is also of cultivated potato on 'Key access and utilization descriptors for cultivated potato genetic resources' in 2009 (http://www.bioversityinternational.org/publications/publications/latest.html).

A practical seed handling and storage book documenting the experience – 'Principles and practices of seed storage' relating to seed genebanking was published (Justice and Bass 1978). This was followed by the publication of a series of genebanking handbooks by IBPGR where the procedures and standards established then are still the norm today. As the result, several key genebank manuals were published (http://www.bioversityinternational.org/publications/publications/latest.html).

This was followed by a period of increased construction of modern genebanks both in CGIAR centers and national genebanks in many countries which number about 1300 (FAO 1996). The IBPGR was evolved into the International Plant Genetic Resources Institute (IPGRI) in 1991 where its activities became more focus on research than the coordinating roles of the IBPGR. In 2006, IPGRI transformed itself into a research institution and renamed as Bioversity International.

Following the increasing utilization of the germplasm and the extensive use of plant breeders rights and patents to protect the derived new cultivars and sometimes extend to the original germplasm genetics used, the debate on the intellectual property rights of the original farmers and their fore-fathers in the development of the genetic resources became an agenda in the 1980s mainly at FAO under the intergovernmental Commission on Genetic Resources for Food and Agriculture and the International Undertaking on Plant Genetic Resources. It was at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro that the full force of the resulting deliberation was tabled where 150 countries signed the Convention on Biological Diversity (CBD) which became effective in November 1993. The status of genetic resources as the common shared heritage and property of humankind became the nature resources of individual sovereign nations. The rules of engagement in germplasm collection, conservation and use change where prior consent on the use, equitable sharing of benefits resulting from the use of the genetics and associate knowledge, and the farmer rights became the matter of bilateral negotiation and agreements between users of germplasm and provider country. The exchange of genetic resources was notably reduced as the result. FAO through its Global Plan of Action for the conservation and use of plant genetic resources was finding a way to revert this and an International Treaty on Plant Genetic Resources for Food and Agriculture was signed and rectified, and went into force in June 2004 (http://www.planttreaty.org/index_en.htm) to create a multi-lateral germplasm exchange and use system with a pass-on standard material transfer agreement (SMTA). To-date, 120 parties have sign-on and the world is in a transition to learn and live with these two systems of germplasm use.

Dynamic conservation strategy as a discipline

Crop genetic resources conservation is, currently, separated into two main strategies: (1) *ex situ* conservation strategy where germplasm samples are collected or acquired and then conserved outside their natural state, and (2) *in situ* conservation strategy when germplasm variation are maintained in their natural environment by the farmers and farming communities, i.e. the genepool is evolving according to the environment pressure offered. The *ex situ* conservation strategy has been the main focus to these days. Well established genebanks have been built like the CGIAR genebanks. In the past fifty years, an interdisciplinary field involving knowledge from more than 25 scientific disciplines has been developed as shown in Fig. 1. However, the knowledge and experience has been concentrated on the *ex situ* conservation strategy in seed and clonal genebanks.

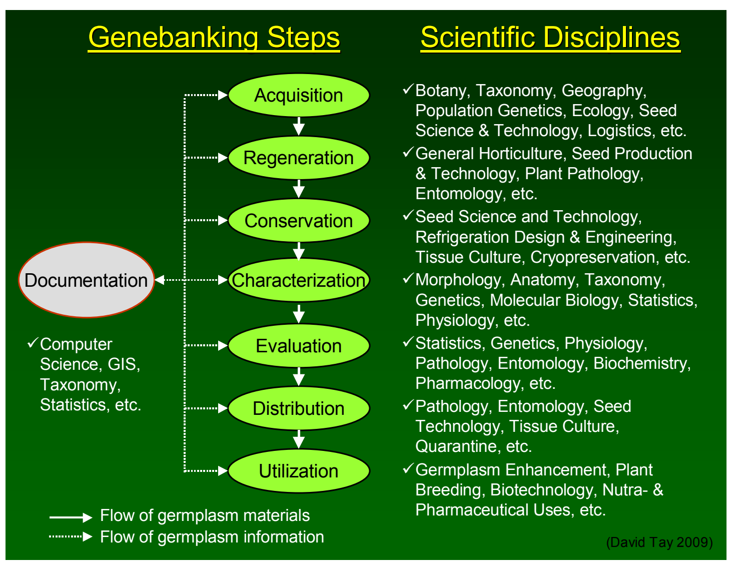

Figure1. The processes and the knowledge relating to the scientific disciplines required in managing and operating a standard *ex situ* genebank for both seed and clonal crops

On the other hand, the *in situ* conservation strategy by nature of its social sciences component has been exploratory and *ad hoc*, and endeavors have been mainly on natural areas and buffer zones relating to the conservation of landraces and wild related species. The interaction of the *in situ* and *ex situ* conservation strategy and their complimentary function were limitedly explored and tested.

At CIP in the last ten years, the interaction of *in situ* and *ex situ* conservation was put to test at San Jose de Aymara, Huancavelica, Peru and the 'Potato Park' in Pisac, Cusco, Peru. Communal genebanks of native potato were established with their own native cultivars collected in their own locations when the project was established and in addition, CIP repatriated all the cleaned virus-indexed native potato from its *ex situ* genebank collected about 30-40 years ago to the respective communities. Technologies and know-how on clean seed maintenance and selection, seed storage, scientific characterization of the cultivars and register and database were provided as a package. Plastic greenhouses were built in support of clean seed production and distribution to neighboring communities. After about ten years of interaction at San Jose de Aymara, the communal genebank is, currently, independently managed by the community and some special cultivars were produced for seed trade and niche markets and thus a self-sustainable *in situ* conservation system is in operation. The community, in addition, takes on the scientific task to produce clean seed for CIP *ex situ* collection for its repatriation program in Peru.

With the success in San Jose de Aymara, an agreement between the Association of the Potato Park Communities, Asociacion ANDES (a non-profit organization in Cuzco) and CIP was signed in December 2004 for five years to duplicate the experience. The results of this project have been widely reported in popular press and news media.

These successes coupled with the experience at CIP in its repatriation program which from 1998-2008 distributed 3608 samples of 1250 accessions of native potato to 41 communities in Peru have led CIP to formulate a regional project to cover the whole range of the Andes from Venezuela in the north to Argentina in the south to establish communal genebanks in their local communities at the micro-centers of agro-biodiversity along the Inca ancient highways. This is 'La Ruta Condor' project – 'the flight path of condor' (Fig. 2). The strategy is to establish site by site based on communal interest and funding availability. At the moment, three more sites are under negotiation in collaboration with the Andean Community and the Mountain Institute.

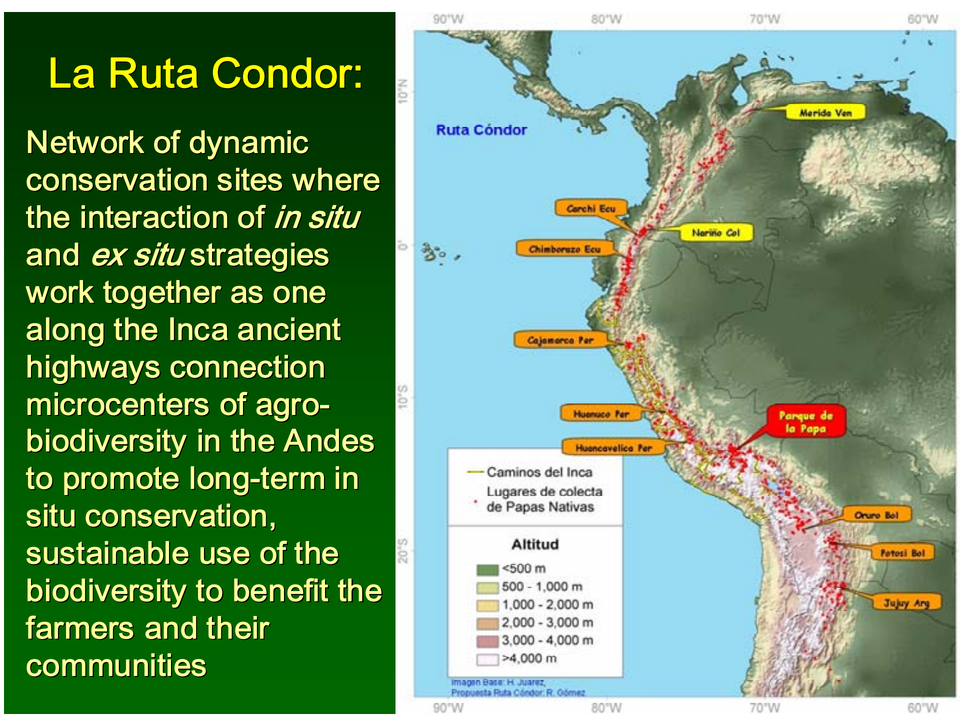

Figure 2. The 'La Ruta Condor' project – a dynamic conservation strategy where the *in situ* and *ex situ* conservation work together in a dynamic way to complimenting the comparative advantage of each

The crop genetic resources conservation in the fifty years has developed and grown into a discipline of study in its own right. There are three scientific journals that specifically publish works in this discipline. We thus recommend the use of dynamic conservation strategy, a discipline of the complimentary use of both *in situ* and *ex situ* methods, in genetic resources conservation program.

What is a model genebank system?

This concept is proposed for the first time to create a network of genebanks of excellence to act as models for other genebanks to follow and to draw expertise from. The primary goal of a model genebank should be to conserve germplasm and related data and information for our future generations. It could be a seed and clonal genebank or a combination of both. A practicing dynamic conservation program where *ex situ* and *in situ* conservation methods interact to compliment each other is a plus as described in the above section. Thus, a model genebank should have the following features:

- A working genebank with comprehensive competency and authority in genebanking of at least one crop
- Implementing international conventions, treaties, standards such as CBD, IT, etc.
- Hands-on in generating genebanking processes and standards in the world or a region
- Proactive in genebanking research and capacity building and training of other genebank staff

What makes a model genebank? It should have a set of qualities as follows:

- Committed staff, i.e. competence & discipline
- Sufficient infrastructure and equipment
- Best practices and discipline
- Distributing clean germplasm
- Full backup of germplasm and information
- Efficient and cost effective
- Sufficient funding

Committed staff. The staff should individually believe in the primary goal of the genebank to curate the genetic resources for our future generations. They should thus be motivated and passionate on their curatorial responsibilities, knowledgeable and skillful in what they do and eager to teach and learn, transparent in handling of germplasm and information (not withholding germplasm and information), take on research only on issues relating to genebanking activities, etc.

Sufficient infrastructure and equipment. The infrastructure requirement is more of functional accuracy and reliability rather than complexity and a well monitoring and maintenance program should be in place and functioning. Seed and *in vitro* cold storage rooms should have a reliable alarm system and a standby generator when main grid electric fell.

Best practices and independent accreditation. The development of genebank management system has evolved since the 1970s where management was based on ones own experience and that of others and then developed to these days a best practice system as illustrated in Fig. 3. Following the creation of IBPGR, common standards were established and genebank management handbooks were published. Common standards were followed such as the -18°C was set for seed long-term storage, and the 15°C and 15% relative humidity for slow seed drying to 3-7% seed moisture content. In the mid 1980s based on these standards FAO initiated a genebank assessment program and each participating genebanks was given a report on its status (personal experience at the AVRDC genebank). However, this program was not continued. This was followed by the use of genebank own operation manual which was a norm in the 1990s to date. The GPG1 and GPG2 have developed best practices for the different genebanking processes. CIP's genebank took the efforts one step further to become the first genebank in the world to obtain the ISO 17025 accreditation where all the best practices are documented, and infrastructure and equipment are calibrated and monitored at set interval. All nonconforming occurrences are documented and corrective actions are formulated and updated on the ISO operation procedures so that the same nonconforming activities will be prevented. It is thus a self-improving best practice system.

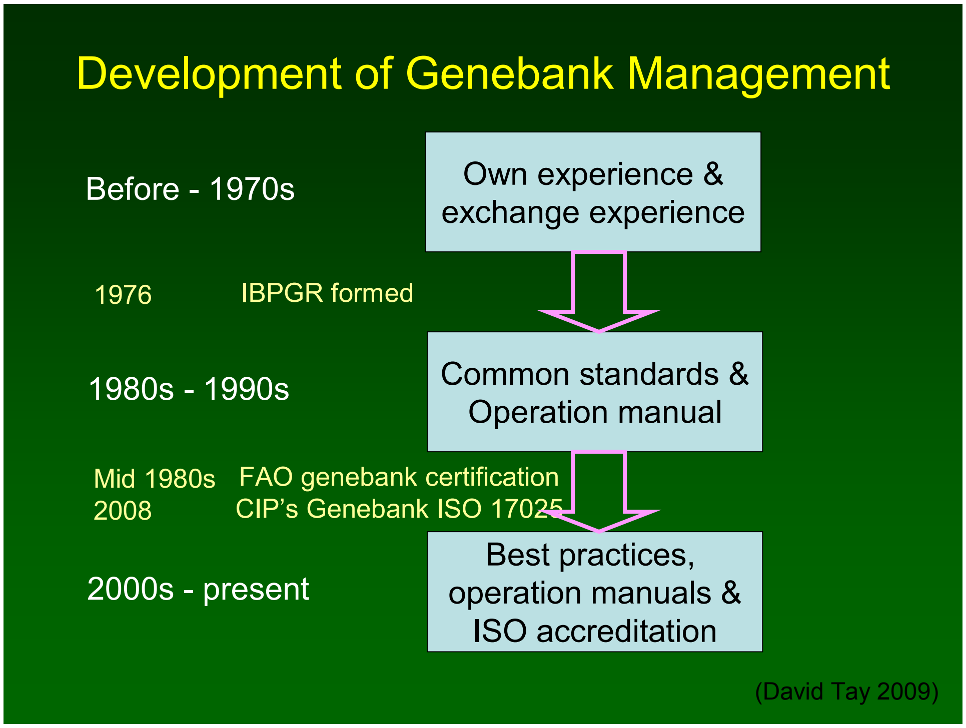

Figure 3: The development and evolution of genebank management system from the 1970s to present

Distributing clean germplasm. This is a must in clonal genebanks where clean vegetative material should be only distributed to prevent the spread of diseases around the world. FAO specific crop guidelines should be the minimum standards to be followed and in addition the recipient country quarantine requirement should be followed. Similar, seed genebank should adopt the best practice in seed production to harvest clean seed and to follow national and international quarantine requirement.

Duplications of germplasm and information. Germplasm collections should be 100% backup at another site of different risk factors. Similarly, hard copy of all germplasm collection, characterization, evaluation and associate information should be kept in an 'information blackbox' and also scanned for digital backup. Similarly, digital images should be backup together with germplasm databases.

Sufficient funding and efficiency and cost effectiveness. Quality work can only be achieved with sufficient fund. However, a genebank should be efficient and cost effective in its operation. Constant supervision and evaluation of the operation processes and outcomes by experience genebank manager is the mean. Periodic benchmarking with similar genebanks will provide the guidance to achieve state of the art.

Why CIP's Genebank is a model genebank?

The CIP's Genebank has 37 years of experience in both seed and clonal which included field-, seed, *in vitro*, cryo-) collections and a supporting DNA bank, a herbarium and a 10-year dynamic conservation program where *in situ* and *ex situ* methods compliment each other in farming communities as described in the above section. In fact, the seed collection at CIP is larger than its clonal collection in term of number of accessions. Some of its qualifications include the following:

- Home of the largest *in vitro* genebank.
- World first genebank with ISO 17025 accreditation – a self-improving continuous best-practice approach.
- Leader in barcode technology, pocket PCs and wireless system where pens and pencils are sparingly use CIP's *in vitro* genebank.
- Quality than quantity collection – where duplicates in the clonal native potato collection have been identified with the most appropriate science of the time and converted to seed and a system to confirm the individual accession identity is carried out .
- Committed to the distribution of only cleaned clonal germplasm where in potato 9 viruses and 1 viriod, and visible bacteria are eliminated and in sweetpotato 11 viruses and other viruses as can be detected by indicator plants and visible bacteria.
- Full implementation of IT and the use of SMTA (Standard Material Transfer Agreement) and CBD requirement in its germplasm distribution.
- Cryo-bank with more than 750 accessions of potato in storage.
- Ten-year experience in dynamic conservation strategy – the complementary role of *in situ* and *ex situ* conservation.
- Recognitions and values the contribution of farmers in the development of the original genetic resources (landraces) and applies this believe in its dynamic conservation projects.
- Genebank operation is fully cost.

CIP Genebank is a leader globally in these key qualifications. It leads the GPG2 task force in these areas in the CGIAR genebanks. CIP genebank is thus a model genebank.

CIP is committed to take on the role as a model genebank and this is in its Cooperate Plan 2009-2018 for implementation (under final revision). The goal is CIP, community conservationists and other stakeholders will collaborate on dynamic *in situ* and *ex situ* conservation of potato, sweetpotato and underutilized root and tuber genetic resources to enhance their use by present and future generations and respond to climate change. The four strategic objectives to fulfill this role as a model genebank are:

1. The holdings of the genebank will represent the entire genepool of potato, sweetpotato and their wild relatives.
2. The holdings of the CIP genebank will be completely characterized for priority traits and the information about it will be freely available and accessible to all users.
3. ISO-accredited quality management systems will cover all relevant aspects of genebank activities to ensure secure conservation and a safe, responsive, decentralized maintenance and distribution service for plant genetic resources.
4. A strategy, methods and tools for CIP, community conservationists and other stakeholders implemented to collaborate on dynamic *in situ* and *ex situ* conservation.

Conclusion

We are at the stage where both the technical aspect of genebanking and the international operational framework in the fair and equitable transfer and use of genetic resources are in place. The model genebank concept with its model genebanks will enhance the development of more high quality genebanks in the world where a genebank can benchmark itself against a model genebank to identify areas that require further improvement. Currently, such a system is not available. CIP genebank as one of the CGIAR genebanks is in an appropriate position to take on this challenge as the first model genebank.

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